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CROSS-STRIKE STRUCTURAL DISCONTINUITIES IN THRUST BELTS, MOSTLY APPALACHIAN

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ABSTRACT

Cross-strike structural discontinuities (CSDs) are fundamental parts of several thrust belts. CSDs are best recognized as structural lineaments or alignments of disruptions in structural or geomorphic patterns. Detailed field studies show that the discontinuities are complex zones of diverse sizes, represent different degrees of basement involvement, and have various structural, geophysical, chemical, and

Table 1. Preliminary characterizations of CSDs. O = phenomenon is present in, and an outstanding characteristic of, the named CSD. P = present. - = unevaluated. A = absent. * = property by which the CSD was first recognized. MP = McAlevys Fort - Port Matilda CSD, Pennsylvania. TM = Tyrone - Mount Union CSD, Pennsylvania. EB = Everett - Bedford CSD, Pennsylvania. PB = Petersburg CSD, West Virginia. PA = Parsons CSD, West Virginia. 38 = extension of 38th Parallel lineament into West Virginia. LN = Little North Mountain CSDs, Virginia. MO = Modoc CSD, West Virginia. WS = White Sulfur Springs CSD, West Virginia. CV = Covington CSD, West Virginia and Virginia. AN = Anniston CSD, Alabama. KC = Kelly Creek CSD, Alabama. HV = Harpersville CSD, Alabama. IR = Irish CSDs. SC = Southern Chilean CSDs (parautochthonous foreland). Dots before and after numbers in the "Spacing" line indicate that the numbers apply to the columns under which the dots appear.

Phenomenon	MP	TM	EB	PB	PA	38	LN	MO	WS	CV	AN	KC	HV	IR	SC
	Named CSD or group of CSDS														
Size (km)															
Length	70+	160+	130	80	55	175+	11-25+	58	48+	36+	270	50	240	200	5-80
Width	1-2	1	1	8	10	80	1-4	5-12	3	-	3-4	1-12	3-4	5	0-1
Depth	-	-	-	5	3	-	-	4	4	-	-	5+	-	-	5
Spacing between CSDs	..20.......		..20-90.	-	-	-	60-90	...15-25......			-	-	-	30	10-15
Structural effects															
Major scale	P*	P	P*	O*	O*	O	O*	O*	O*	O*	O	O*	O	O*	O
Minor scale	P*	P	-	-	P	-	P	A	A	A	P	P	P	-	O
Microscopic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
More fracturing	P	P	P	-	P	P	-	-	-	-	-	-	-	-	O*
Dip separation	A	A	A	A	A	-	P	A	A	-	P	P	P	-	P
Strike separation	A	A	P	A	A	P	-	-	-	-	-	P	-	-	O
Faulting reversal	P	P	-	-	A	-	P	-	-	-	A	P	A	-	P
Geophysical effects															
Gravity anomalies	-	P	P	P	P	P	-	P	P	P	P	-	-	P	P
Magnetic anomalies	-	P	P	-	-	-	P	P	-	P	P	-	-	P	-
Seismic activity	A	P	P	-	-	-	-	-	-	-	P	P	P	-	P
Fluids: Effects on...															
Sulfides	-	P	P	-	-	P	-	-	-	-	P	A	P	P	P
Quartz, calcite	P	P	P	-	-	-	-	-	-	-	-	P	-	-	P
Magmatic activity	A	A	A	A	A	P	A	-	-	-	-	A	-	P	P
Thermal waters	A	A	A	-	-	P	A	-	-	-	A	A	A	P	-
Oil and gas yields	-	-	P	P	-	-	A	-	-	-	A	A	A	-	P
Water-well yields	P	-	-	-	P	-	-	-	-	-	P	O	P	-	-
Water-well quality	-	-	-	-	P	-	-	-	-	-	A	-	A	-	-
Other effects															
Sedimentation patterns	-	P	-	-	-	P	-	-	-	-	P	A	P	-	-
Extent into basement	-	-	P	-	A	-	-	-	-	-	P	A	P	P	P
At outcrop scale	-	P	-	P	A	-	P	-	-	-	A	P	A	P	P*
Microscopic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Satellite photos	O	O	O	O	P	O*	P	P	P	O	P*	O	O*	P	P
Air photos	P	A	A	O	P	A	P	P	P	O	P	P	P	-	O
Geomorphic	P	O*	P	O	A	P	P	P	P	O	P	P	P	P	O
Drainage anomalies	P	P	P*	O	P	P	P	P	P	P	P	P	P	P	P
Most likely origin(s)															
Step-up along trend	-	P	-	P	P	P	P	A	P	P	-	O	-	-	-
Tear-fault zone	-	-	-	-	A	P	-	-	-	-	P	O	A	-	P
Active basement	-	-	P	A	A	-	A	-	-	-	P	A	P	P	P
Passive basement	P	-	-	-	-	P	-	-	-	-	P	A	P	-	-
Other	-	-	-	-	-	-	-	P	A	A	-	-	-	-	-

other characteristics. CSDs are not single surfaces, such as tear faults, joint zones, or outcropping unconformities. They can affect concentration and quality of hydrocarbons, mineralizing fluids, or ground water.

INTRODUCTION

In a symposium in 1976 we described preliminary results and speculations from current field studies of major cross-strike structural discontinuities (CSDs), in allochthonous or parautochthonous parts of three orogens. The CSDs described are map-scale structural lineaments or alignments, at high angles to regional strikes, and best recognized as disruptions in strike-parallel structural or geomorphic patterns (see below and Table 1). This paper summarizes results reported at the 1976 symposium, and subsequent work, (1) to promote exchanges between the authors and other field geologists working on similar structures in widely separated areas, and (2) to attempt a preliminary characterization of a class of structures of growing academic and economic interest. This paper contains some preliminary generalizations, and cites available work on the areas described at the session. Table 1 summarizes the characteristics of 15 CSDs or groups of CSDs. Details have been or will be published separately by individual authors. Work on most of our CSDs is incomplete, so only 13 of the 81 cited references are articles in established journals or series; all are readily available however, if one knows that they exist.

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GENERALIZATIONS

CSDs form an important class of major structures, located in, but in some places extending beyond, petroliferous and metalliferous thrust belts. Individual CSDs are too poorly known for us to decide yet whether all have the same or similar relationships to orogeny or plate tectonics, to figure a typical example, or to formulate an exact definition. Also, the list in Table 1 is geographically biased toward the central and southern Appalachians, and is surely incomplete (see, for example, Dahlstrom, 1970, Price and Lis, 1975, Lis and Price, 1976, and Price and Kluvver, 1974; also oral communications from R. A. Price on the Canadian Rockies and H. P. Laubscher on the Jura, at the Penrose Conference on Relative Chronology of Thrusting in the Southern and Central Appalachians). However, we predict that CSDs are generally characteristic of allochthonous and perhaps parautochthonous fold and thrust belts.

CSDs should not be classed with simple tear faults or joint zones and can be considerably more complex than either. CSDs' differences may be as important as their similarities. CSDs are not single surfaces. Many may include hundreds of cubic kilometers of rock, which are volumes of economic and academic importance in their own rights, with their own physical and chemical properties. Some CSDs are deep, nearly vertical zones, but others are apparently wider than deep. Some but not all CSDs contain unusually fractured rock.

Basement (suballochthon rock and structure) may or may not be involved in any given CSD. Basement involvement can be active, the basement becoming part of the final CSD, or it can be passive, the older inactive basement structures influencing formation of structures in an allochthon passing overhead. Basement involvement might also change from active to passive to nonexistent, craton-ward along a single CSD. Perhaps active and passive basement involvement can be distinguished by comparing the gravity, magnetic, and seismic signatures, which can characterize the rocks over which an allochthon now sits, with early-acquired chemical signatures, which, if identifiable, can be

characteristics of the rocks over which the allochthon once passed.

For both academic and economic reasons, it is important to determine what CSDs do to the rock at and within their boundaries, in both penetrative and non-penetrative senses. To what predictable extents do CSDs or their boundaries possess unusual degrees of fracture porosity, fracture permeability, variation in fold style or intensity, hydrothermal mineralization, cementation, or recrystallization?

It is not yet clear how one best prospects for CSDs. Because of their diverse characters and expressions (see Table 1), the process of finding them reliably and of determining or predicting their properties and extents is much more complex than just seeking straight lines or alignments on photographs and maps. Not all CSDs are visible on aerial photographs, and not all are outstandingly visible on satellite imagery (Table 1). On the other hand, the field methods being used to define and characterize several CSDs are probably too time-consuming to be applied to more than a few field areas, on which faster methods can then be tested before their application to new areas.

TERMINOLOGY

Unnecessary confusion has already arisen over terminology, partly because workers are scattered and CSDs are complex, and partly because study of CSDs spans several branches of geology not always in close contact (for instance, detailed field mapping and interpretation of LANDSAT images). Terminology standardization is beyond the scope of this paper but should be done soon, while the number of geologists working on CSDs is still small.

A few CSDs appear to form where a detachment fault cuts upsection to shallower structural levels; this process can occur in two ways: (1) The fault can step up across regional trend, on a reverse fault or fault zone that strikes perpendicular to the transport direction, or (2) it can step up along regional trend, on a strike-slip fault or fault zone that strikes parallel to the transport direction. The first way produces an anticline, and the second forms an end or lower edge of a detached block. For schematic examples, see Harris's (1970, page 171) diagrams. At least 11 terms are in common or local use for one or both of those methods of cutting upsection: ramp, step, riser, longitudinal fault, longitudinal step, step fault, cross fault, tear fault, transverse fault, transverse step, and domain boundary. The words "transverse" and "longitudinal" are surprisingly confusing in the context of CSDs, because a longitudinal step (usually a reverse fault, though the term has been used for a strike-slip fault) has transverse motion. Some writers refer to the structure and the motion on it almost interchangably. Having one term to include both types of steps seems unnecessarily confusing. For cross-strike structural discontinuities whose nature and cause are not clear, the general term "structural lineament" seems applicable and conformable with recommended usage (for example, see Lattman, 1958, and Werner, 1976).

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